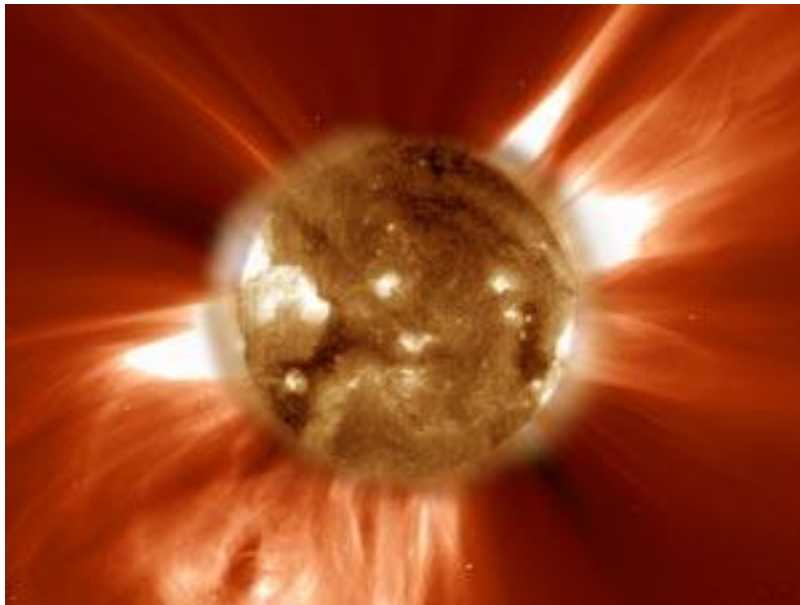
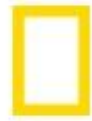


Satellites and Large Space Weather Events



—Illustration from European Space Agency via AP

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Solar Megastorm Could Cripple Satellites for a Decade

Satellites not strong enough to withstand sun's explosions, model shows.

Ker Than, for [National Geographic News](#), Published September 20, 2012

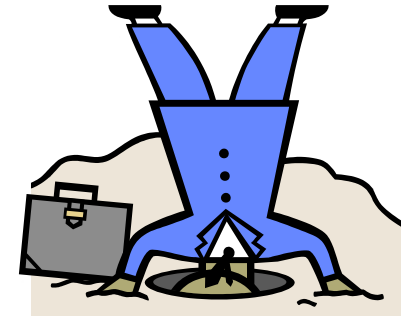
- ‘Though the results are still preliminary, Shprits predicts that a majority of the LEO satellite fleet could be lost within a few years of such an event.’
- ‘The model shows "there is probably a threat to satellites during [megastorms]," Green said in an email. She cautioned, however, that the model is based on many assumptions and simplifications that will have to be tested further.’

Considering Large Events

Doomsday predictions



Dismissive Complacency



VS

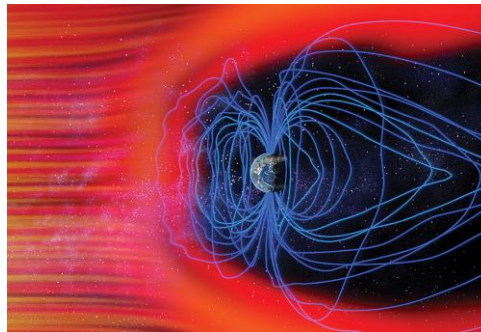
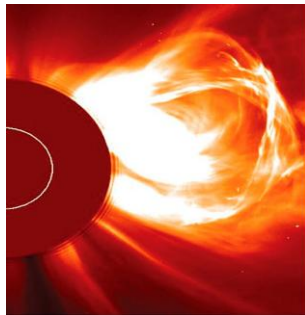


Responsibly Prepared

Goal: To be responsibly prepared by analyzing possible scenarios and providing realistic hazard assessments to decision makers

Questions

1. Does a large space radiation event pose a significant threat to the satellite infrastructure with societal implications?
2. If so, what can or should be done before, during and after the event?

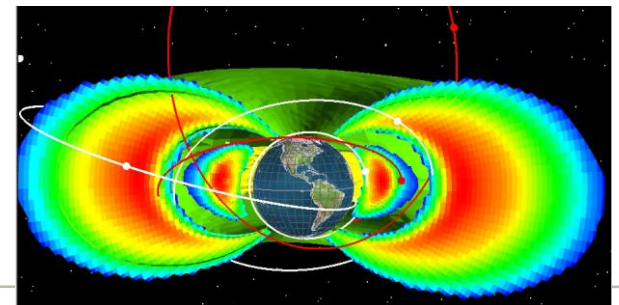
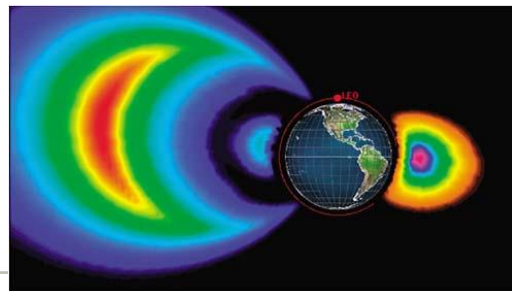


Responsibly Prepared

1. Know the satellite system limits and consequences of exceeding those limits
2. Define the likelihood that the environment will exceed those limits
3. Understand the societal impacts
4. Monitor the environment for large events
5. Have a plan in place for when the large event occurs

1. Know the system limits and consequences of exceeding those limits

- Is there a standard set of requirements that most satellites are designed to meet?
 - For example: Are most satellites at GEO/LEO designed to withstand the AE/AP8max or other model flux levels? Are there standard margins used?
 - Is the response beyond those levels tested and known?
 - Standard system limits could be used to provide better alerts.



2.0 Define the likelihood that the environment will exceed the design limits

- Can this be done with physics based models?
 - Very challenging. Radiation intensity depends heavily on unknown parameters.
- Can it be done with extreme value statistics?
 - Possibly. But only in well sampled regions with many satellites in similar orbits like GEO.
- Both.
 - Create a reanalysis dataset of the near space environment using data assimilation in physics based models.
 - Then fly a satellite orbit through and apply extreme value statistics to get the probability of events exceeding a threshold at any specific orbit.

3. Understand the societal impacts

- Is there a significant societal impact?
 - “The current fleet of approximately 250 satellites represents an approximately \$75 billion investment with a revenue stream in excess of \$25 billion per year, or greater than \$250 billion over the life of these satellites.” - [Severe Space Weather Events--Understanding Societal and Economic Impacts: A Workshop Report](#) (2008) Space Studies Board
 - What are the interdependencies?
 - Is additional risk assessment needed?
- Would better anomaly reporting help define impacts?
 - Should NGDC revive its anomaly database?
 - Is there a way to make anomaly reporting simple and feasible?
What should be included in a standard report or template?

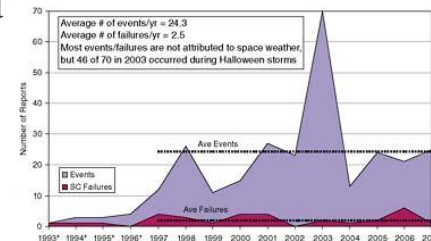
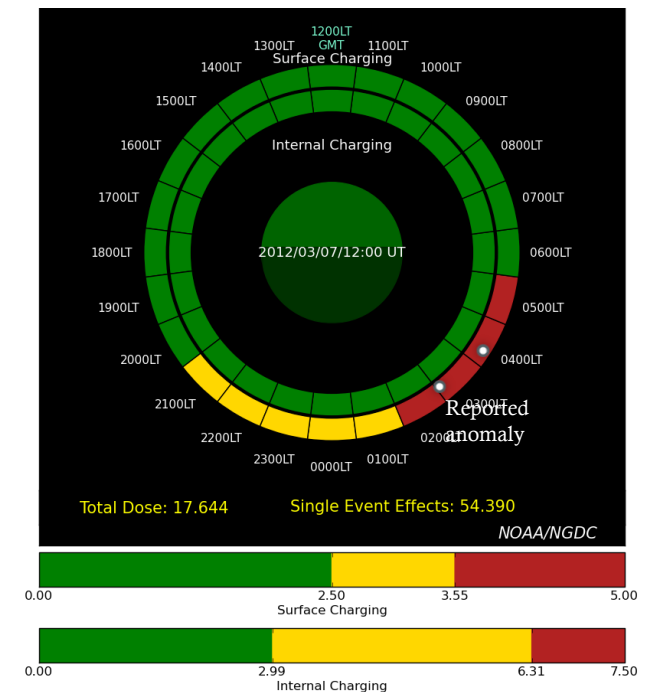


FIGURE 2.9 Space weather and satellite anomalies/failures. SOURCE: Michael Bodeau, Northrop Grumman, “Impacts of Space Weather on Satellite Operators and Their Customers,” presentation to the space weather workshop, May 22, 2008.

4. Monitor the real time environment

- NOAA monitors proton and electron fluxes with the GOES and POES satellites
- Would an extreme flux alert be valuable?
 - Fluxes or fluences have surpassed the highest level ever recorded?
 - Fluxes or fluences have surpassed standard design limits?
 - Would real-time anomaly reporting be at all feasible? Real time anomaly reports could be added to model projections of the environment.



5. Have a plan in place

- Can anything be done during a large event to make systems less vulnerable and when is it worth doing?
- What about after? Does there need to be national or international coordination should an event occur that causes some significant fraction of satellites to fail?